

PARENT BODY ALTERATION OF LARGE METAL INCLUSIONS IN THE CM CARBONACEOUS CHONDRITE, MURRAY N. P. Hanowski and A. J. Brearley, Institute of Meteoritics, Dept. of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131.

Introduction

The concept of parent body aqueous alteration in order to explain the ubiquity of phyllosilicates in CM chondrites has been largely established on the basis of compositional and textural evidence [e.g.1,2,3]. Much of this textural evidence is equivocal and alternative models, such as, nebular alteration [4] yield plausible explanations for many observations. Many aspects of the parent body alteration model, such as the role of brecciation, the spatial extent of chemical exchange and the mechanisms involved in the alteration process of CM chondrites are all important, but as yet unresolved issues. Here we present unambiguous textural evidence from Murray, one of the least altered CM chondrites, that in situ alteration was important during the early alteration of Fe, Ni metal which mobilized Fe over a range of several hundred microns.

Observations

Backscattered electron (BSE) images from two thin sections of Murray show several large, rounded inclusions in matrix and chondrule fragments consisting entirely of secondary, Fe, Ni-rich phases (Fe up to 42wt%, Ni up to 13wt%) with characteristic textures and diameters around 250 μ m. Troilite as the precursor of these inclusions can be excluded, because troilite appears to be largely unaltered, for example, in type IIA chondrules even when present as smaller grains and in close proximity to the inclusions. Except for a lower S (<5wt%) and higher Ni and Cr (up to 3wt%) contents the altered inclusions are compositionally and especially texturally similar to smaller, bleb-shaped grains in type IA and type IAB chondrules in Murray. The morphologies of these smaller grains and their tochilinitic composition (S>8wt%; Ni<7wt%, Cr<1wt%) indicate Fe, Ni metal as the anhydrous precursor phase as suggested for other CM chondrites [5,6]. These similarities and the high Ni content of the large inclusions indicate that their precursors were also Fe, Ni metal. All the large, altered, inclusions are surrounded by conspicuous aureoles of relatively Fe-rich, fine-grained matrix material enclosing several chondrules and mineral fragments. The Fe-rich aureole shown in Fig.1, for example, protrudes radially over several hundred microns in all directions and also affects the fine-grained rims of several chondrules. The outer margin of this aureole shows the highest Fe concentrations and is in sharp contrast with the surrounding more Mg-rich matrix material. Data obtained from quantitative X-ray maps of the area indicate an enrichment

of between 5wt%-10wt% Fe for fine-grained material in the aureole in comparison with the surrounding matrix whereas S appears to be depleted in the aureole. Mass balance calculations unambiguously attribute the increased Fe content in the aureole to the alteration and Fe-depletion of the inclusion at the center. Compositional profiles through the altered inclusion obtained with a 1 μ m electron beam show increased Si, Al, Mg, Fe and Na contents towards the edge, whereas Ni and Cr are enriched at the core.

Discussion

The Fe-enriched aureoles surrounding the altered inclusions in Murray clearly represent reaction halos resulting from the in situ breakdown of primary Fe, Ni metal during aqueous alteration. This is unequivocally demonstrated by the evidence that the reaction aureole encloses intact chondrules, chondrule rims, mineral fragments and matrix. These observations of early, but advanced in situ alteration, completely rule out the possibility of nebular alteration in this case. Abundant mineral fragments in the aureole may indicate parent body brecciation, but the undisturbed appearance of the aureole also shows that the brecciation process was either rapidly declining in intensity or had completely ceased before significant metal alteration occurred. The ubiquity of reaction aureoles around completely altered inclusions in Murray and their compositional and textural uniformity argue against an introduction of these inclusions into their current locations late in the brecciation and alteration history. The distinct zonation in terms of Si, Al, Mg and Na contents in the inclusion may record a gradually progressing transformation towards the interior whereas the depletion of Fe suggests the preferential incorporation of Fe into matrix serpentine of the aureole. The low S concentrations in the aureole indicate that the formation of S-bearing secondary phases (probably tochilinite) in the inclusions also effectively removes S from the surrounding regions. All observed ranges of elemental mobility are around several hundred microns which is consistent with CM chondrite alteration being essentially isochemical on the thin section scale and low water/rock ratios during CM chondrite alteration. This result is further supported by the similar bulk compositions of all CM chondrites regardless of their alteration degree. One implication of the presence of Fe-rich aureoles in the matrix of Murray is that attempts to constrain the alteration degree of CM chondrites using Mg concentration of the matrix will be hampered by local hetero-

geneities resulting from the alteration of large metal inclusions. In addition, it is evident that models which suggest metal as a precursor of PCP-rich objects [4,6] are not compatible with our observations, because PCP-rich objects in Murray matrix are texturally and compositionally distinct from altered metal in chondrules and matrix.

References

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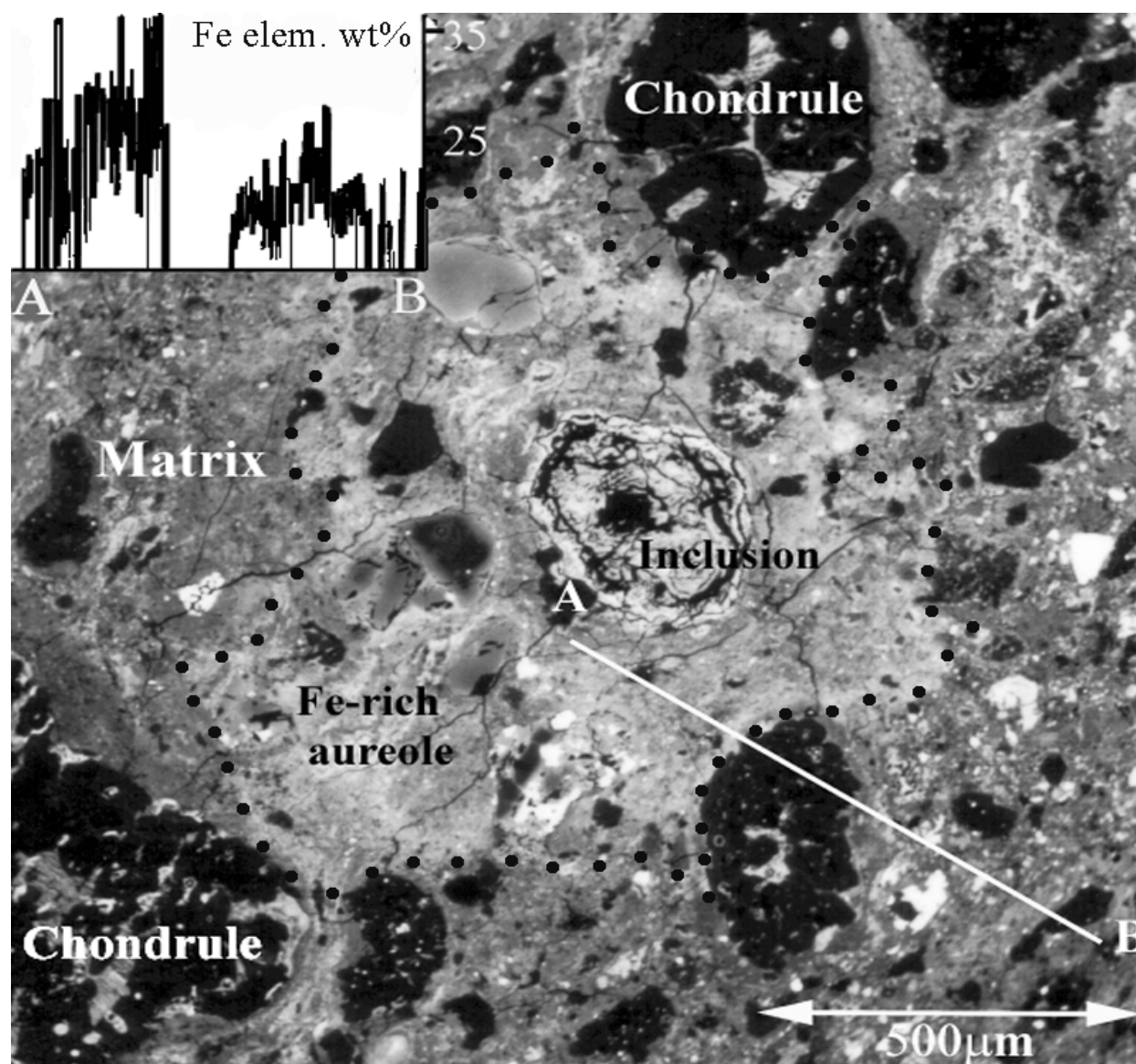


Fig.1 An altered Fe,Ni metal inclusion with a Fe-rich aureole in Murray. The profile a-b indicates the drop in Fe content from matrix and chondrule rim inside the Fe-rich aureole to the external chondrule rim and matrix.